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LAKE STATES ASPEN REPORT NO. 4

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MILLING OF ASPEN INTO LUMBER

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FOREWORD

During and since World War II, there has been increasing interest in aspen (*Populus tremuloides*) in the Lake States, its availability and supply, properties and uses, and management. Aspen is a tree of primary importance in 20 million acres or 40 percent of the total forest area of the three Lake States - Michigan, Minnesota, and Wisconsin.

At an informal meeting at Madison, Wisconsin, in January, 1947, forestry representatives of several federal, state, and industrial groups in the Lake States agreed that it would be desirable to bring up to date what is known on aspen and make it available to anyone interested. The job of preparing this information in the form of reports was assigned to each of the groups listed below. The reports will be duplicated as rapidly as completed, and the entire project should be finished by the end of 1947. Each report will concern one aspect of the subject. Copies will be available from the Lake States Forest Experiment Station or from each contributor.

Report Number	Subject
1	Aspen Properties and Uses
2	Aspen Availability and Supply
3	Logging Methods and Peeling of Aspen
4	Milling of Aspen into Lumber
5	Seasoning of Aspen
6	Aspen Lumber Grades and Characteristics
7	Mechanical Properties of Aspen
8	Machining and Related Properties of Aspen
9	Aspen Lumber for Building Purposes
10	Aspen for Containers
11	Aspen for Core Stock
12	Small Dimension and Other Industrial Uses of Aspen
13	Aspen for Veneer
14	Aspen for Pulp and Paper
15	Aspen for Cabin Logs
16	Aspen for Excelsior
17	Aspen Defiberization and Refining of Product
18	Chemical Utilization of Aspen
19	Preservative Treatment of Aspen
20	Marketing of Aspen
21	Possibilities of Managing Aspen

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REPORT NO. 4

MILLING OF ASPEN INTO LUMBER

By
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Forest Products Laboratory 1/

In the manufacture of aspen lumber, the costs of stumpage and logging approximate 65 per cent of the total, and milling and sales 35 per cent. Milling efficiency is essential, but by itself it is not assurance of a profitable operation.

The costs of milling aspen conform to the general rule that costs per M board feet increase as log diameters decrease. Aspen is a small log species; normally in the Lake States only a very small proportion of aspen logs exceeds 12 inches in diameter at the small end, and the average log of sawmill size is likely to be about 8 inches. Large mills designed to cut old-growth timber normally lose money on logs under 12 inches. In the shift from old-growth timber to second-growth throughout the country, milling equipment is being evolved specifically designed for small-log utilization. Various types of sawmills are coming into prominence. They are not all new but are indicative of increasing interest in comparing one type with another. Studies have been made by the Forest Products Laboratory on four different types of equipment for milling aspen, viz.: (1) portable single circular, (2) portable gang circular, (3) round log sash gang, (4) splitter and horizontal resaw. Comparative performance of these four types is summarized along with a brief discussion of other types of sawmills developed or in process of development.

The data in table 1 are directly comparable. All mills studied were cutting lumber of 1-inch nominal thickness. Two operations were cutting other than 8-foot lengths, but their output has been adjusted to 8 feet. Also, adjustments have been made for those mills cutting too thick or too thin lumber. Each type of equipment is assumed to cut logs of similar diameters into square-edge lumber measured by similar standards.2/ The distribution of logs by diameter class as shown in table 2 is based on that for the portable single circular operation and is assumed to be typical for aspen sawlogs.

1/ Maintained by the U. S. Department of Agriculture, Forest Service, in cooperation with the University of Wisconsin, Madison, Wisconsin.

2/ Data on the sash gang were taken in 1941, prior to that for the others, and lumber measurement standards may vary from them.

Table 1.--Cost and production data for four types of small-log milling equipment

Type of sawmill	Initial investment for complete mill 1947	Production per hour	Man hours per M board feet lumber: Log yard to sorter 1/	Man hours per M board feet lumber: Log yard through lumber pile or kiln trucks 2/	Lumber yield per average log 3/	Percent of boards accurately sawn 4/	Calculated machine costs per M board feet lumber: Depreciation	Calculated machine costs per M board feet lumber: Maintenance
	Dollars	Bd.ft.	Man-hours	Man-hours	Bd.ft.		Dollars	Dollars
Portable single circular	4,600	999	3.00	6.86	19.9	74	0.46	0.90
Portable gang circular	9,000	1,363	3.67	6.61	16.9	48	1.05	0.97
Round log sash gang	60,000	2,168	2.31	6.47	23.3	98	1.29	1.22
Splitter and horizontal resaw	66,000	3,176	2.52	5.98	21.4	58	0.77	1.20

1/ Normal work delays included, viz.:
Portable circular = 20.8 percent
Gang circular = 30.4 percent
Round log sash gang = 12 percent
Splitter-horizontal resaw = 14.9 percent
Moving delays excluded.

2/ Both normal work delay and moving delay included, viz.:
Moving delay portable circular = 14.3 percent
Gang circular = 12.6 percent

3/ Average log 7.9 inches d.i.b.

4/ Thickness measurements are grouped by 1/32-inch divisions and the three divisions recording the higher percentage are added to give a measure of relative prevision set up as a good standard.

The conclusions to be drawn from these figures are:

(1) The circular portables, either single or gang, require relatively low capital investment as compared to the round log sash gang or the splitter resaw. Depreciated over the expected life and production, the cost per M board feet shows some variation, but it certainly is not significantly important. The same is true of the maintenance cost per M board feet.

(2) The portable mills are relatively low-capacity units; the other two are high-capacity, considering the size of logs sawed.

(3) The man-hours per M board feet show considerable spread in percentage comparing one machine with another (log yard to sorter), but show surprising uniformity when comparison is for the entire job (log yard to pile).

(4) A marked difference exists between the different types of equipment in the amount sawed from similar-sized logs. For the log size distribution shown in table 2, the extreme spread is 37.9 percent. For logs from which the portable single circular saws cut 1 M board feet, the portable gang circular saws 849, the sash gang, 1,171, and the splitter-resaw, 1,075 board feet. These differences are due to at least three factors. The first factor is the difference in saw kerf. When compared with the portable single circular, the effect of kerf is estimated to be -2.8 per cent for the portable gang circular, +14 per cent for the sash gang, and +11 per cent for the splitter-resaw. The second factor is the difference in thickness variation of the lumber. Compared with the portable single circular, the difference is -2.1 per cent for the portable gang circular, +3.5 per cent for the sash gang, and -.1 per cent for the splitter resaw. The third factor is the difference in log defect and form, for which no figures are given.

Logging of aspen is not dealt with in this report, but any comparison of portable and nonportable mills is incomplete if logging costs are ignored. The major factor in relative costs of portable and nonportable mill operations is that in the former it is lumber that is hauled and in the latter it is logs. Approximately three times as much salable material can be trucked per load when air-dry lumber is hauled rather than green logs.

The effect of the length of haul where logs are skidded directly to the deck of portable mills compared with trucking to permanent mills can be approximated. To compare the cost difference in using a mill as a portable (logs skidded directly to deck) as against the same type as a permanent (logs trucked) at various hauling distances, a formula is: The cost of loading and unloading logs + 2 x cost per mile per M board feet of trucking lumber x number of miles of round trip distance = cost of loading and unloading lumber.

Table 2.--Lumber tally for 1-inch lumber from 8-foot logs

Log diameter inside bark	Percent of logs in diameter class	Log scale		Lumber tally outrun by log d.i.b. for 1-inch lumber from 8-foot logs 1/			
		Scribner Decimal C rule	International ¼-inch rule	Single portable circular	Gang circular	Round log sash gang	Splitter horizontal resaw
Inches							
4	--		0	2.7	3.7		5.4
5	4.4	0	5.0	5.5	6.2	6.0	7.1
6	15.6	5.0	10.0	9.2	9.0	9.5	9.8
7	24.1	10.0	10.0	14.0	12.2	16.9	14.3
8	23.9	10.0	15.0	19.3	15.7	24.0	21.3
9	16.6	20.0	20.0	25.6	21.3	30.6	28.3
10	7.8	30.0	30.0	32.7	27.2	36.9	35.5
11	3.8	30.0	35.0	40.4	33.5	45.7	43.1
12	2.5	40.0	45.0	49.1	40.7	53.2	51.4
13	.6	50.0	55.0	58.0	48.0	63.2	60.1
14	.3	60.0	65.0	68.6	56.7	71.8	69.9
Average		13.9	16.5	19.9	16.9	23.3	21.4

1/ Actual thickness set at efficient one for type of equipment assuming minimum acceptable thickness as 30/32 inch green.

Table 3.--Comparison of permanent mill sets versus portable mills as affected by trucking distances

Trucking distances (round trip)	Gain per M board feet, lumber tally, by using -			
	Circular mill		Circular mill portable	Splitter, resaw as permanent set
	Portable	Permanent set		
Miles	Dollars	Dollars	Dollars	Dollars
10	1.40			0.78
18½				No difference
20	2.50		0.14	
30	3.60		1.06	
40	4.70		1.98	
50	5.80		2.90	

The above comparisons are based on assumed costs per M board feet, lumber tally, as follows:

Increase in recovery of splitter resaw over circular	Logging chance development costs	Stumpage cost	Felling and bucking	Skidding cost	Loading costs		Unloading costs		Cost of trucking lumber per mile
					Logs	Lumber	Logs	Lumber	
Per cent	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
10.9	2.69	3.30	6.40	4.04	1.41	1.00	0.51	0.62	0.055

Truckload capacity, 10,000 pounds = 1.5 M bd. ft. logs, or 4.5 M bd. ft. lumber.

To compare mill types having different kerf thickness where the permanent type employs the thinner kerf a formula is: cost of loading and unloading logs + 2 x cost per mile per M board feet of trucking lumber x number of miles round-trip distances - (sum of logging and stumpage cost) x percentage increased recovery of thin over thick saw 3/ = cost of loading and unloading lumber. All costs are on a per-M-board-feet lumber tally basis. When the lumber trucking cost factor is less, the advantage is with the portable; when greater, the advantage is with the permanent; or the break-even distance can be found by substituting x for miles and finding its value.

The splitter-resaw shows an advantage up to 18 miles round-trip trucking distance and the portable-circular an advantage beyond this. Under the conditions assumed, the portable circular mill excels the circular used as a permanent at all distances. Similar calculations comparing the single circular portable with the sash gang permanent indicate that the break-even distance is 28 miles round-trip truck haul, the advantage being with the sash gang up to this distance.

DESCRIPTION OF EQUIPMENT AND OPERATING TECHNIQUE OF FOUR TYPES OF MILLS

Portable Single Circular

For the efficient use of this type of mill, logs are skidded directly from the stump to the deck either with the track type of caterpillar or horses. Two units, each consisting of one feller-bucker, one driver, and one horse, can normally supply a mill producing 1 M board feet per hour when skidding distances do not exceed 600 feet. In aspen stands some 50 to 100 M board feet can ordinarily be cut within this skid zone; then the mill is moved.

Mills are relatively light (3,500 to 4,000 pounds) but should be provided with feed works permitting quick reversing and fast feed. The type where two friction wheels alternately engage a driven wheel to the drum transmission provides this. Saws are insert-point type, 40 to 48 inches in diameter. A 42-inch, 8 gage saw run at 600 r.p.m. by a unit actually delivering 60 horsepower and having 34, B-type, 9/32-inch swage insert-point teeth is effective. The setting is done either by the sawyer or a carriage rider. The latter is likely to prove faster and provide accurately sawed lumber if the Knight type of dog is used on the front post. No dog is used on the other upright. The sawyer turns the log; the deck skid tops at 30 inches from the floor enable this to be done readily on logs up to 11 inches without the use of the cant hook. In setups where the sawyer does the setting, there is no carriage rider, but a deck man is used.

3/ A rough rule is to allow 2.8 per cent increase for each 1/32 inch thinner kerf.

The latter turns the logs and operates the rear dog. This type of setup employs a spike dog, which is not particularly effective in bringing the cant tight against the upright, and sawing accuracy is likely to suffer. Logs up to about 10 inches are live-sawed, the first face-sawed until near the center, then turned 180°, and finished. Larger logs may be reduced on two opposite faces, then turned up 90°, and sawed as long as the dogs hold, turned 180°, and finished. If thick stock is desired, it is taken from the cuts through the central portion, never near the slab. An edger placed about 17 feet (saw mandrel to edger mandrel) behind the saw, plus the power unit, completes the equipment. Six or seven men operating the mill and piling the lumber can average 1 M board feet per hour. Lumber is placed on scoots behind the edger and pulled to the pile site by the skid unit. Slabs and edgings are racked opposite the edger. A cable with one end anchored about 50 feet in a line at right angles to the tracks and brought under the rack can be returned over the top of a bundle, the horse hooked to the loose end, and the refuse pulled to the dump.

Portable Gang Circular

The equipment consists of a power unit, edger, and log-reducing unit mounted on a semitrailer. Its use in aspen areas would be similar to the portable circular, and moved only as the skid distance got out of balance. As indicated in table 1, this unit is not as efficient as the portable circular. The possibility of speeding up production through faster feeds has not been explored, and the equipment may have development possibilities. Logs are fed by a continuous chain which returns just ahead of the saws to a double series (7 top and 7 bottom) of saws. Rift saws, either 24 inches or 28 inches in diameter, carrying 6 or 12 insert-point teeth, B-type, 10/32-inch swage, are used. The feed chain speed is 36 feet per minute. A crew of nine men (mill crew) can saw and pile 1,363 board feet per hour.

Round Log Sash Gang

The equipment consists of the log-reducing unit, log and lumber conveyor equipment, edger and power units. The log-reducing unit has a series of saw blades rigidly fixed in a sash that moves up and down between guides in the framing. Operating speeds are 330 cutting strokes per minute. The cutting is done on the downstroke. Round logs are fed by rolls to the saws at speeds varying with log size. In logs 7 inches and under, the rate is 14.8 feet per minute; in logs 14 inches, 8.8 feet per minute. This takes into consideration the delays incident to daily operation. A crew of 14, servicing and operating a single unit mill, can saw and pile 2,168 board feet per hour. As indicated in table 1, the operating costs per M board feet are not significantly different from the other type. The real advantage appears in the better utilization of the log. The saws are 14 gage swaged to about 1/8-inch kerf and the resulting boards can be cut accurately to the thickness desired, if logs are smooth. Knotty logs may result in a partial twist from projections passing

the rolls with consequent sawing inaccuracies. Partly due to this and for greater efficiency the company operating the sash gang on round logs has superseded this by installing two band headsaws, three sash gangs, and a horizontal resaw. Small and crooked logs are split on the headsaw and finished on the resaw. Logs large enough to slab about a 5-inch face or more from two opposite sides are thus slabbed and worked down to a 6-inch thickness. The slabs are sent to the resaw if productive of merchantable stock, the cants are sawed by the gangs, one placed on top of another, thus feeding two at once. Much edging is thus accomplished, and by resawing slabs excellent utilization is had. The capacity of a mill of this type is over 12 M board feet per hour. Such types are difficult to justify under normally limited log supply and transportation conditions in aspen conversion.

A combination offering promise, but so far as known not tested, is a small band headrig backed by one or more sash gang resaws and edgers.

Splitter-resaw

This equipment consists of a circular saw centered in a trough which splits logs as the lugged chain carries them through, conveyor equipment to carry the half-logs to a horizontal band resaw, and return and outgoing conveyors for the material beyond the band. The circular saw is 52 inches in diameter, 8 gage, 36 B-F insert teeth swaged 9/32-inch, and run at 600 r.p.m. The band has 62-inch wheels, a double bed, and carries a saw 9 inches wide, 16 gage with teeth swaged to 11 gage. The wheels operate at 416 r.p.m., and the feed rolls at 76 feet per minute. Usually three pieces of aspen can be fed at a time. With this equipment, 19 men (service and operating) can saw and pile 3,176 board feet per hour. It is relatively efficient, but produces lumber of considerable thickness variation, and puts a serious load on the edger.

A variant of the splitter-resaw adds a circular headsaw with standard small carriage. The larger logs or those with center rot can be sent to this side for better grade recovery. A crew of 36 (servicing and operating) can produce an output of 5 M board feet per hour.

GENERAL CONCLUSIONS

The conclusions to be drawn from these studies are that no marked differences are found in milling costs (labor, maintenance, depreciation) between the different types. The effect of increased recovery due to thinner saws, including the influence on logging and hauling costs, is to produce cheaper lumber from mills with lesser sawdust waste, hence the circular mill is less efficient than the sash gang or splitter-resaw if it is used as a permanent set. But the three to one differential due to hauling dry lumber as against green logs plus the capacity of the circular and the inability of the others to

be used as portables results in putting a premium on certain mill types for definite trucking zones. For the values used in this comparison, the circular used as a portable will produce lumber cheaper than the splitter-resaw type where the round-trip hauling distance exceeds about 18 miles and cheaper than the sash gang beyond 28 miles. This probably is representative of a general condition, but it is recommended that specific percentages of recovery increase and costs applicable to the prospective job be used in the formulae by individual operators.